Lawrence Berkeley National Laboratory and the Helios Project

Regents Meeting
17 January, 2007

Lawrence Berkeley National Laboratory

3,800 employees, ~$520 M / year budget

11 employees were awarded the Nobel Prize,
(9 did their Nobel work at the Lab.)

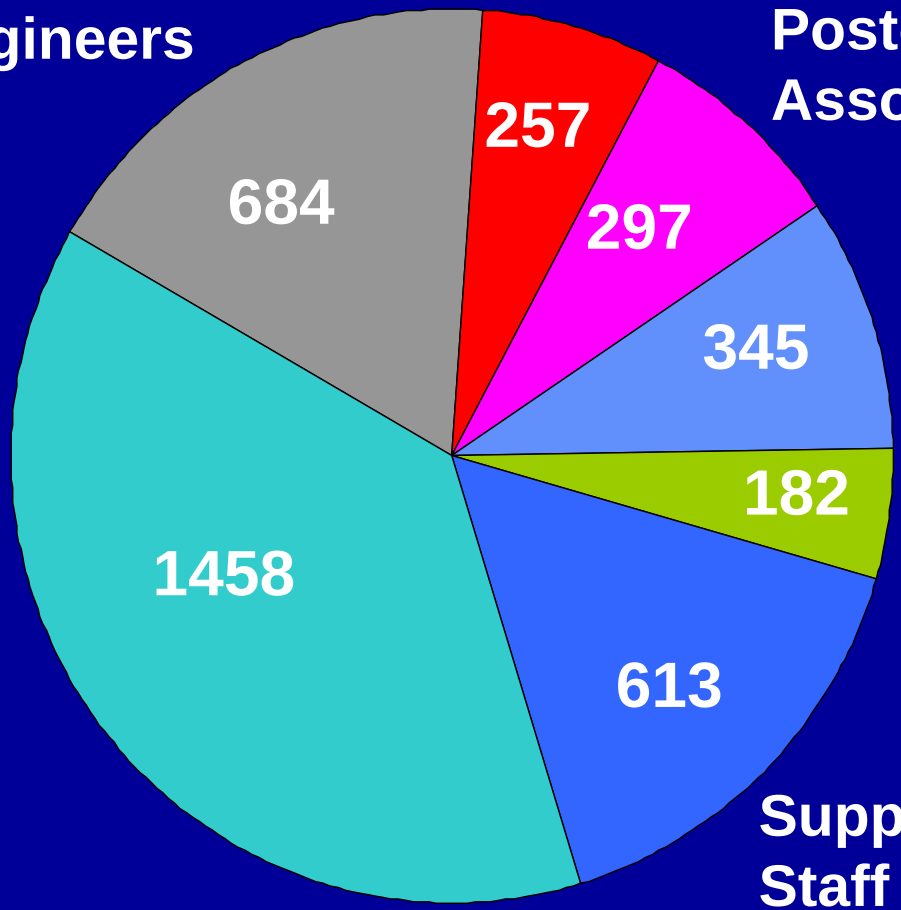
Berkeley
Lab 200
acre site

Today:

59 employees in the National Academy of Sciences,
18 in the National Academy of Engineering,
2 in the Institute of Medicine

UC Berkeley
Campus

Berkeley Lab Staff

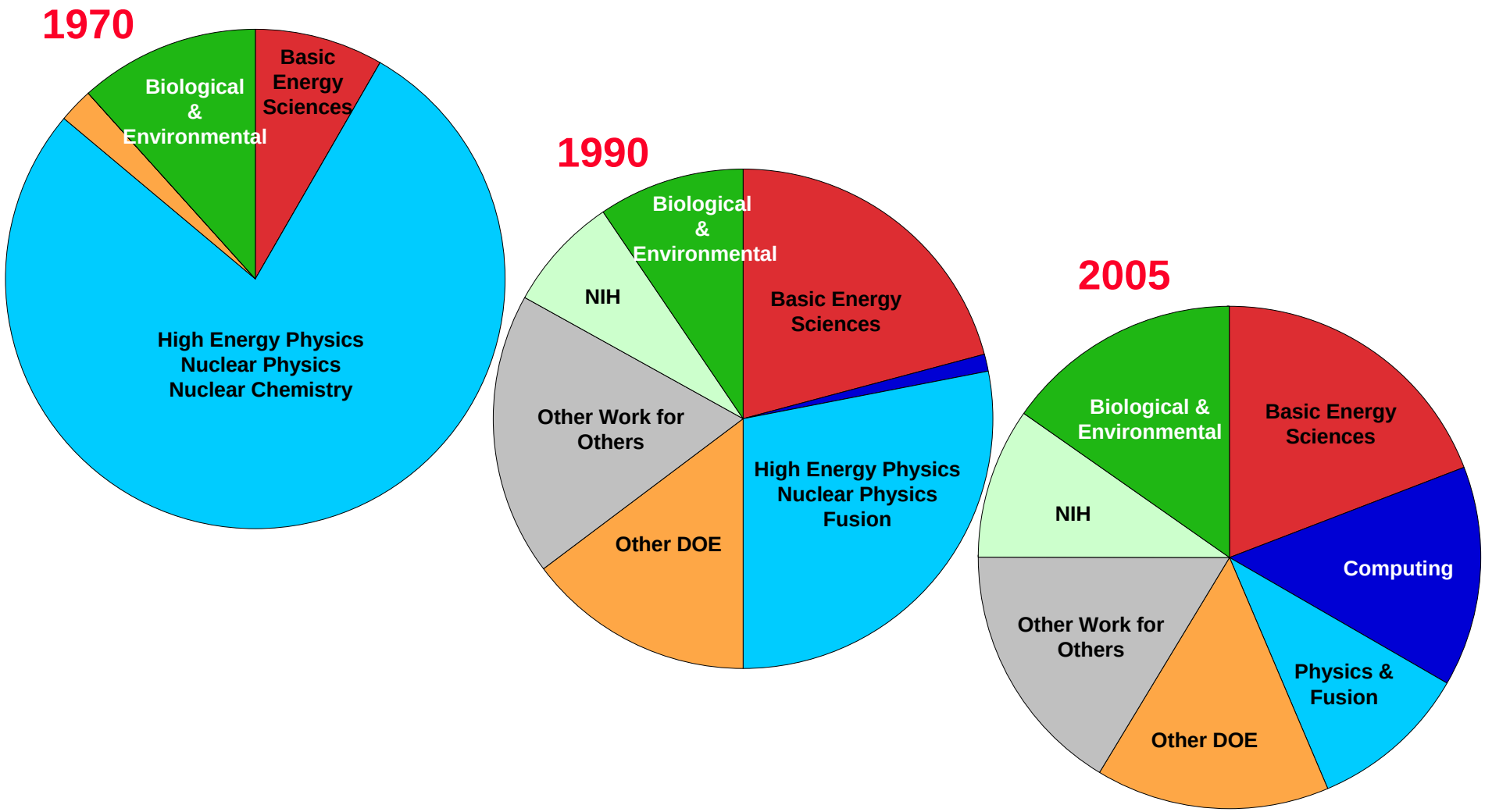


Staff:	3836
Guests:	3007
Total:	*6843*

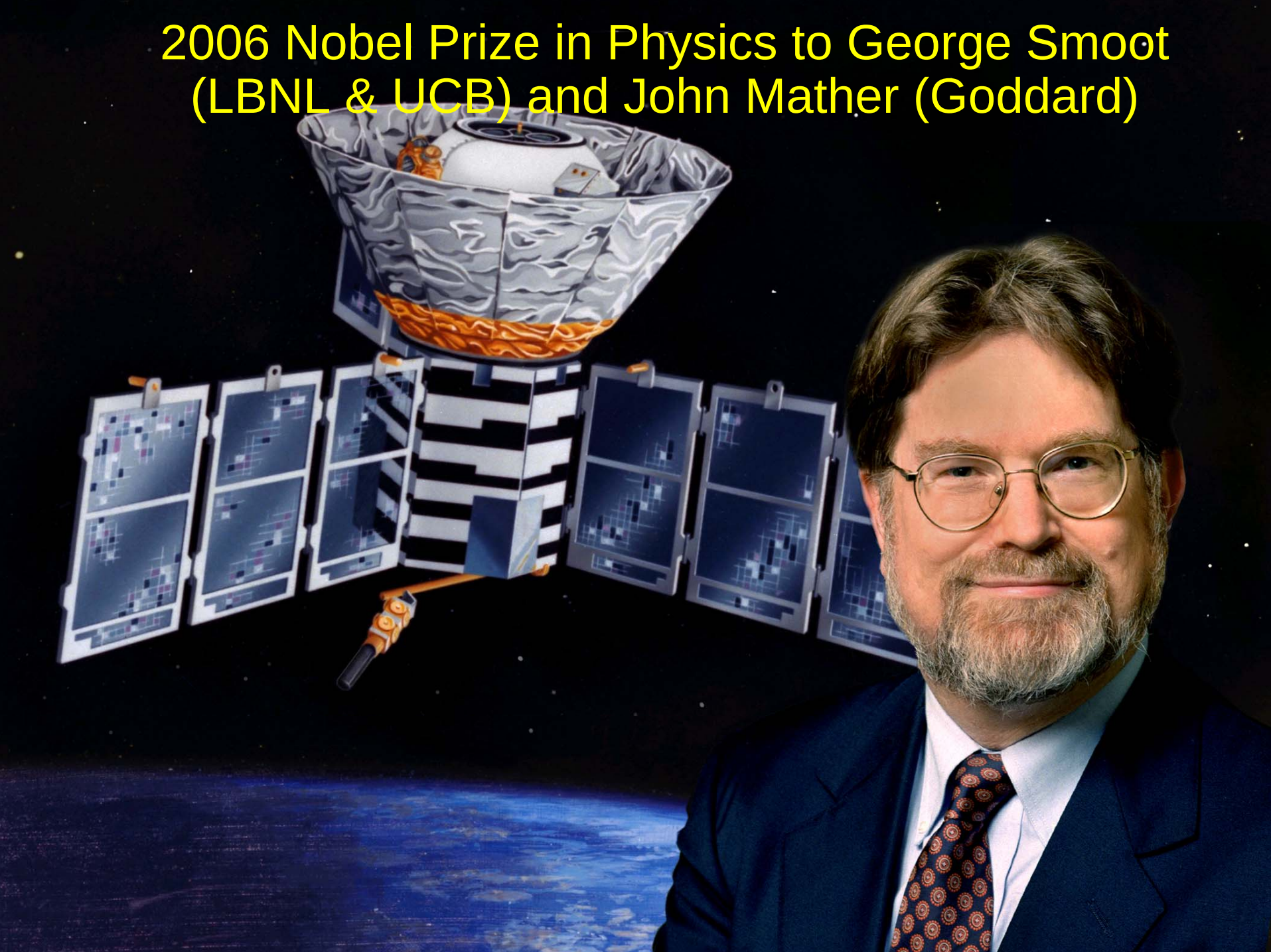
July 2004

E.O. Lawrence introduced the idea of "team science"

Change in Program Share of Berkeley Lab Budget

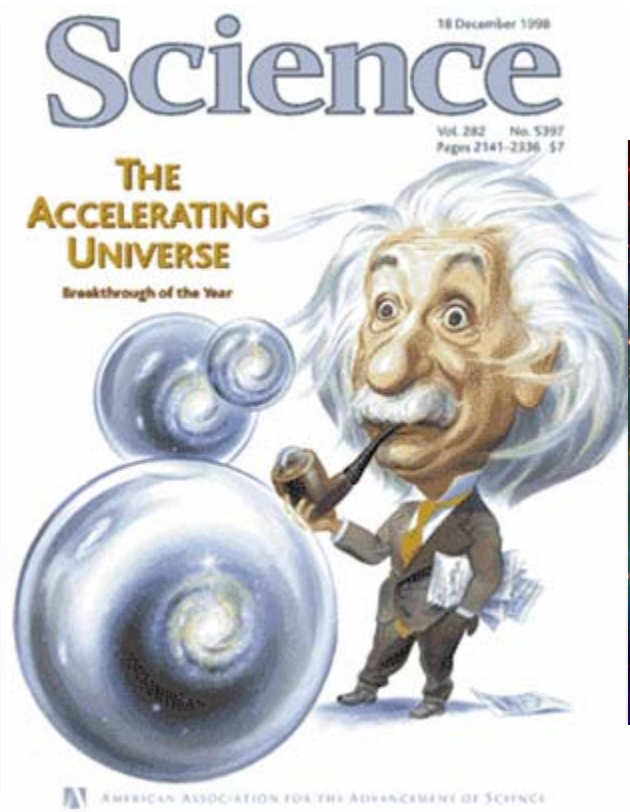


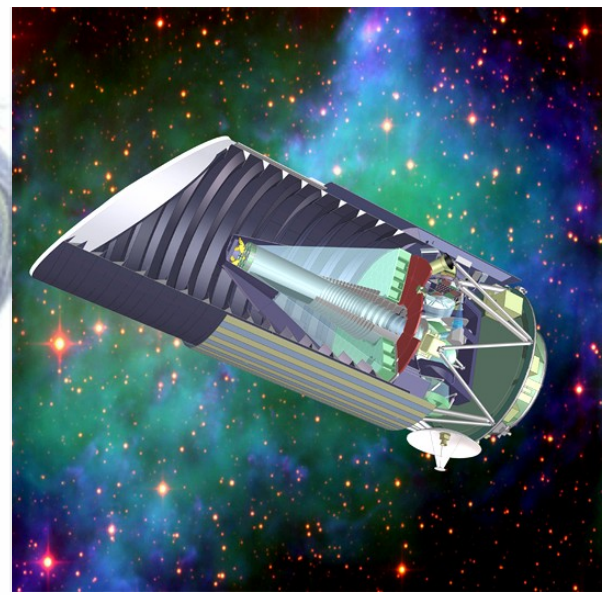
2006 Nobel Prize in Physics to George Smoot (LBNL & UCB) and John Mather (Goddard)



The discovery of Dark Energy

Saul Perlmutter
(2006 Run Run Shaw Prize, Fretinelli Prize)





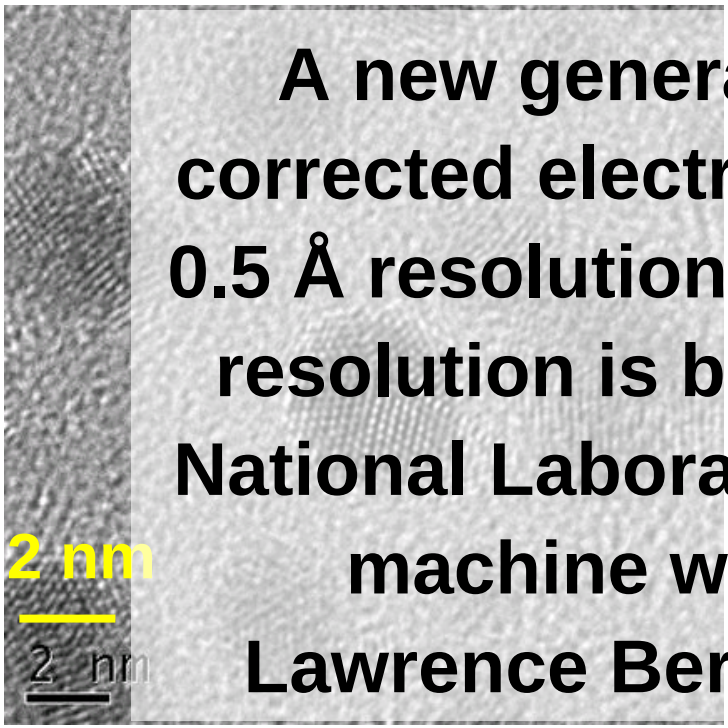
Advanced Light Source

(materials science, advanced lithography, biology)

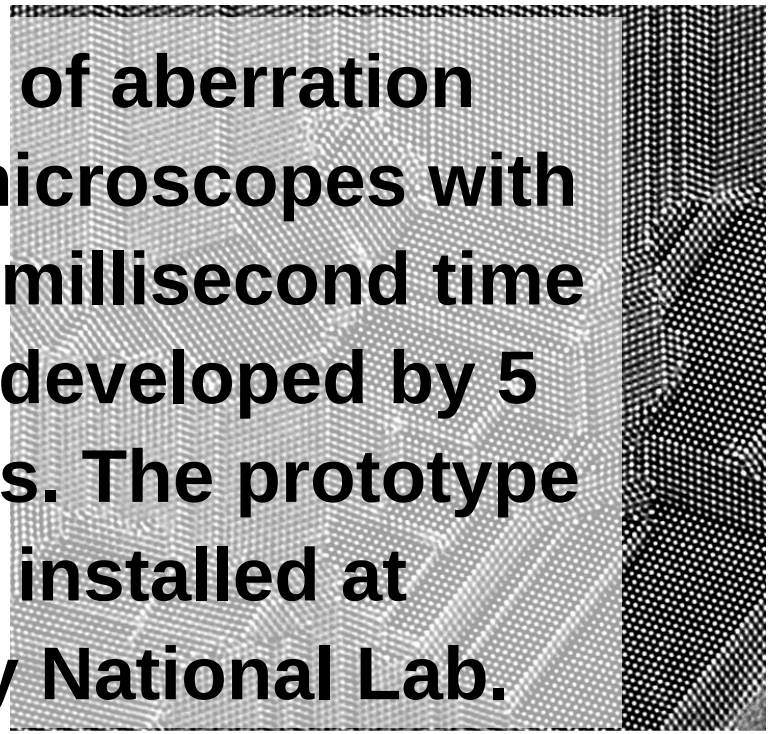
Roger Kornberg, 2006 Chemistry Nobel Prize work was done at the ALS; Rod MacKinnon, 2003 Nobel Prize also takes his data here

National Center for Electron Microscopy

A new generation of aberration corrected electron microscopes with 0.5 Å resolution and millisecond time resolution is being developed by 5 National Laboratories. The prototype machine will be installed at Lawrence Berkeley National Lab.



Gold nano-particles
2 - 3 nm diameter



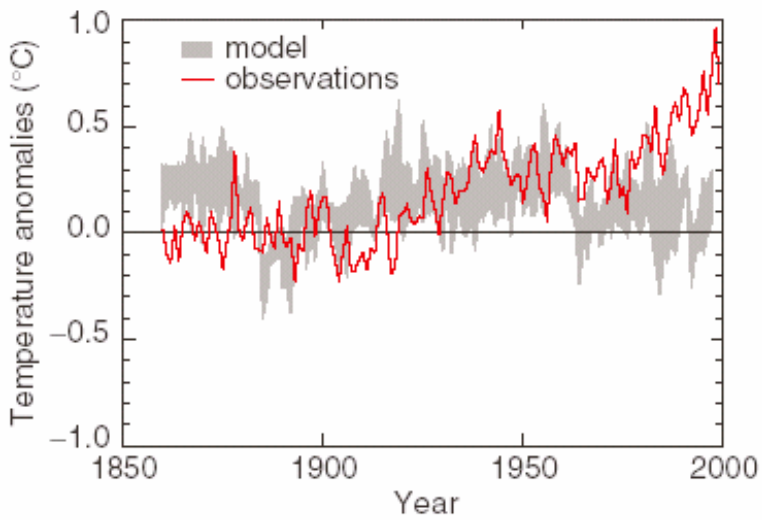
Multiply-twinned nano-crystalline silicon film

National Energy Research Scientific Computing Center (NERSC)

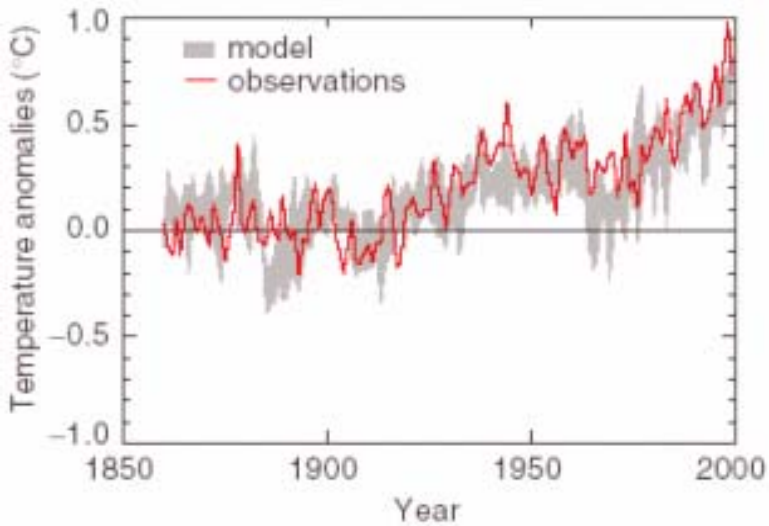
The Energy problem and Lawrence Berkeley Lab's plans

- National security and energy security are intimately linked
- Economic prosperity
- The environment

Temperature rise due to human emission of greenhouse gases



Climate change due to natural causes (solar variations, volcanoes, etc.)



Climate change due to natural causes and human generated greenhouse gases

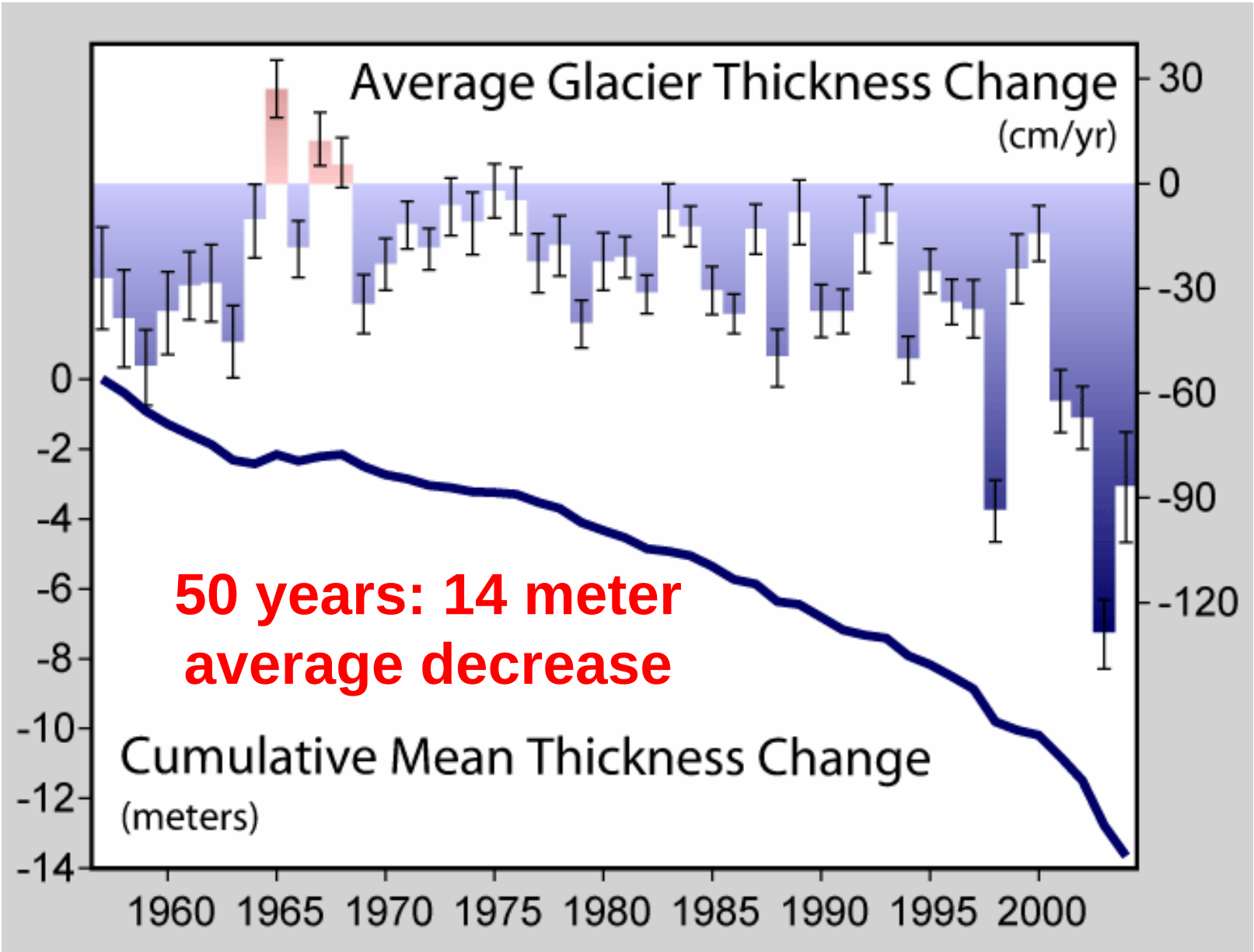
Emissions pathways, climate change, and impacts on California

K. Hayhoea, et al., PNAS 101, 12422 (2004)

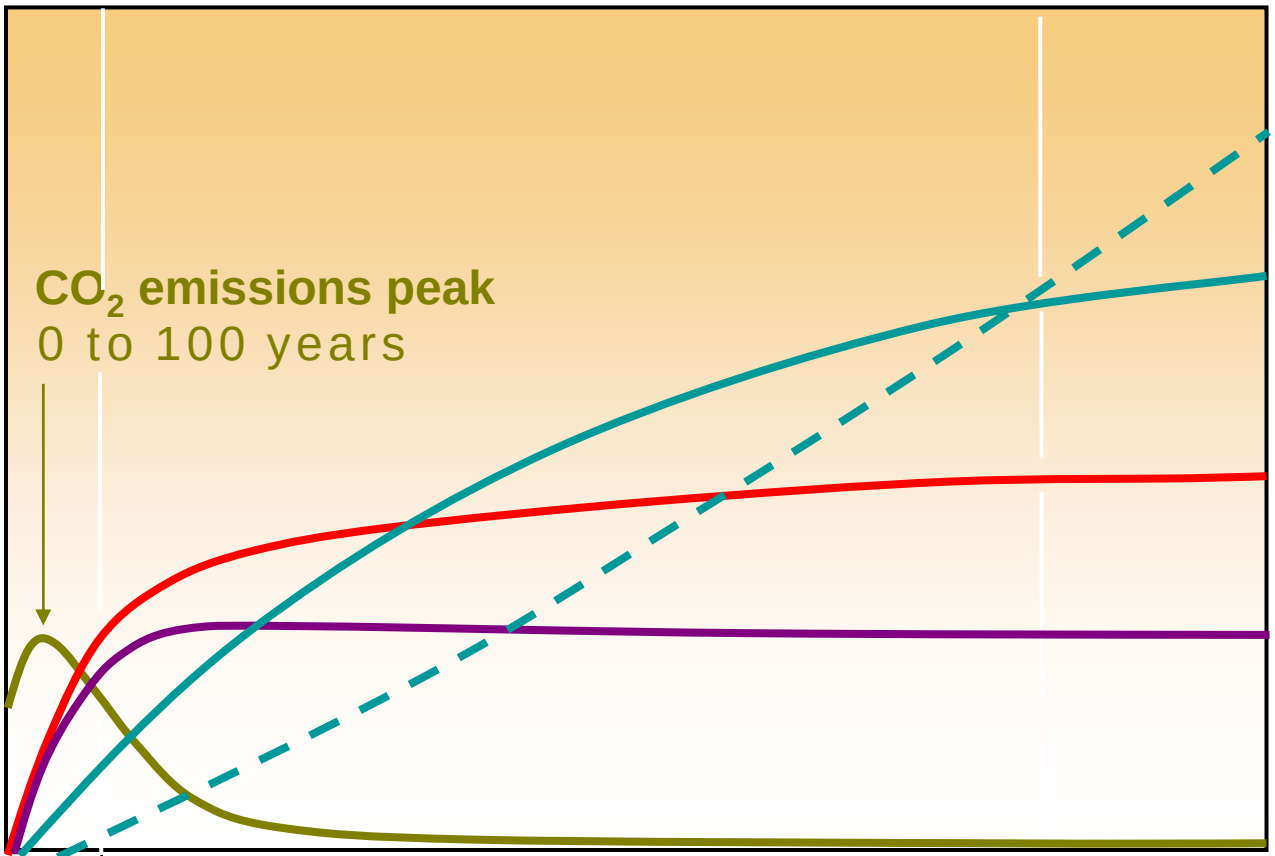
	Aggressive control of GHG	Business as usual
Sierra snowpack	**30–70%**	**73–90%**

"…[this] could fundamentally disrupt California's water rights system."

Snowpack and glacier water sources all over the world will be affected.


Average Glacier Thickness Change
(cm/yr)
30
0
-30
-60
-90
-120
0
-2
-4
-6
-8
-10
-12
-14
50 years: 14 meter
average decrease
Cumulative Mean Thickness Change
(meters)
1960 1965 1970 1975 1980 1985 1990 1995 2000

CO_2 Concentration, Temperature, and Sea Level will rise long after Emissions are Reduced



Sea-level rise due to ice melting: several millennia

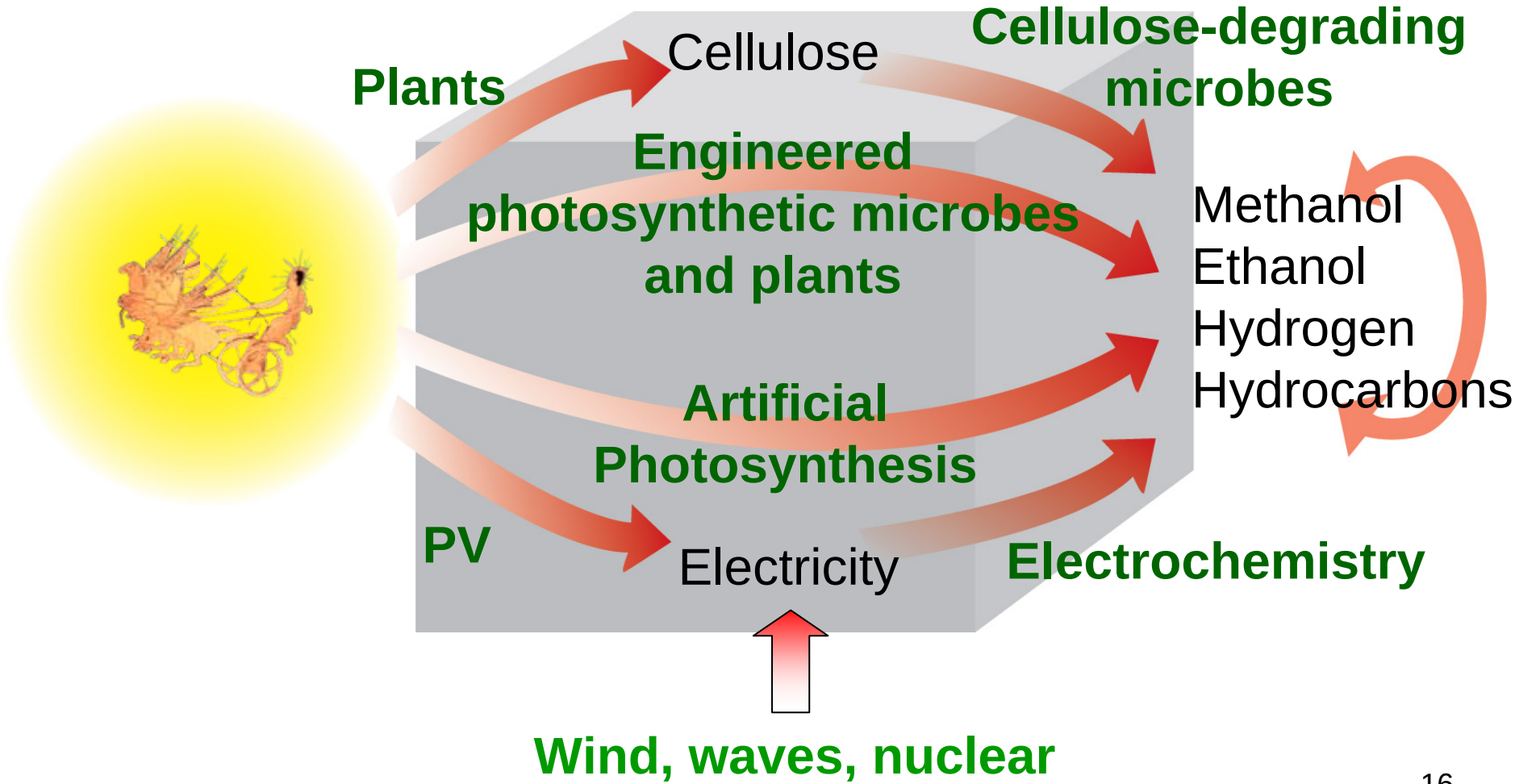
Sea-level rise due to thermal expansion: centuries to millennia

Temperature stabilization: a few centuries

CO_2 stabilization: 100 to 300 years

CO_2 emissions

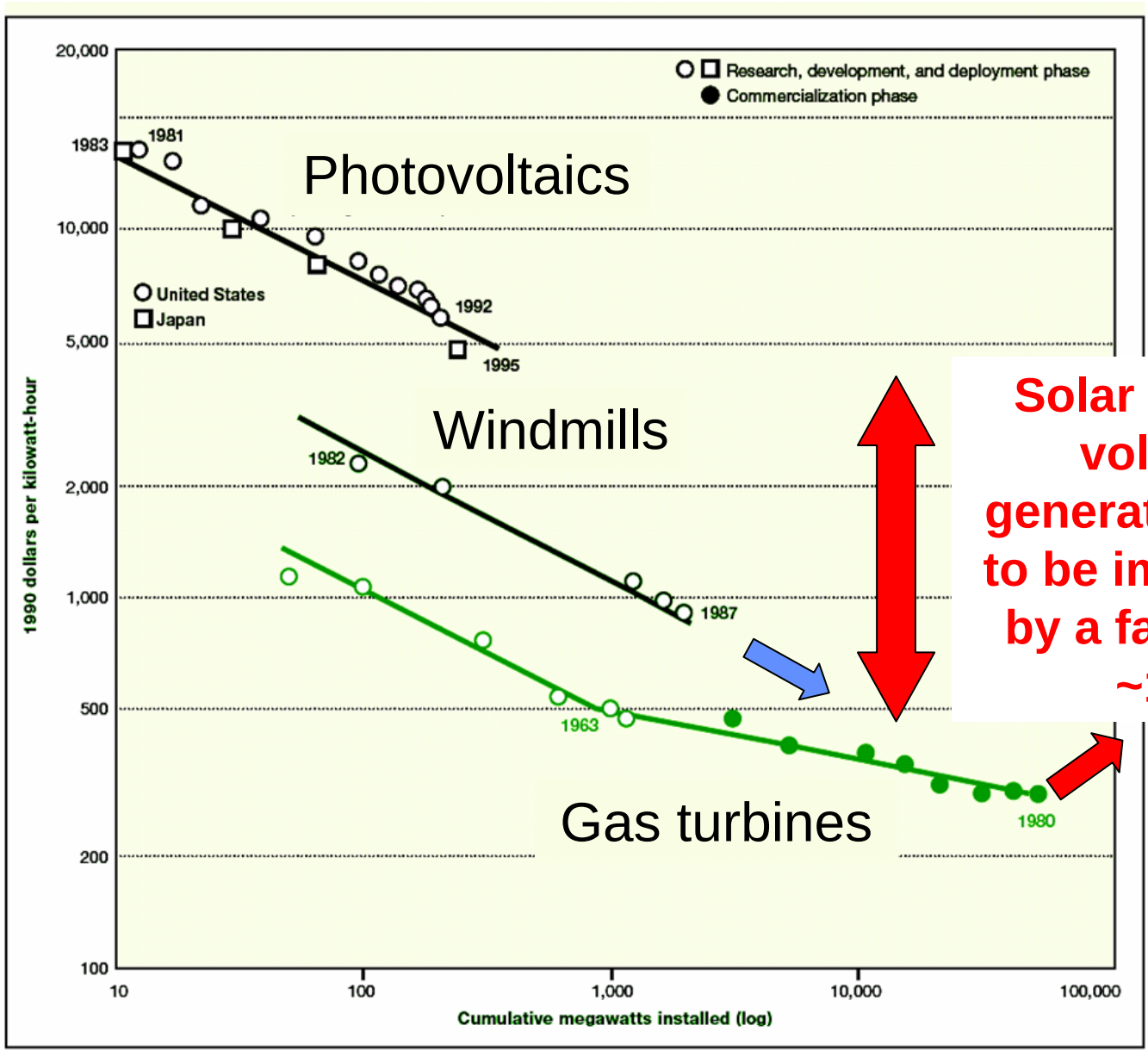
Helios: Lawrence Berkeley Laboratory's attack on the energy problem



Area requirements to satisfy all US electricity at 15% efficiency

J.A. Turner, *Science* **285** 1999, p. 687.

Cost of electricity generation
(1990 dollars/kilowatt hour)

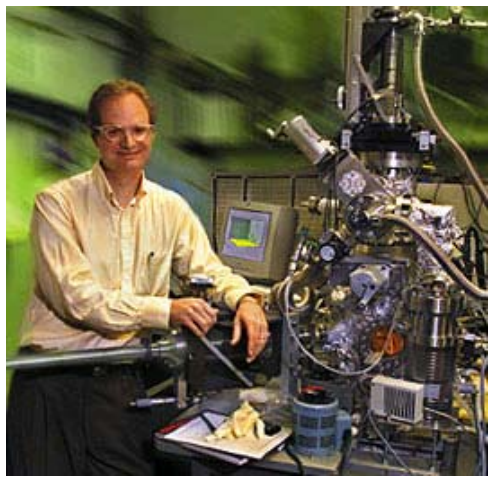


Solar photo-voltaic generation has to be improved by a factor of ~10

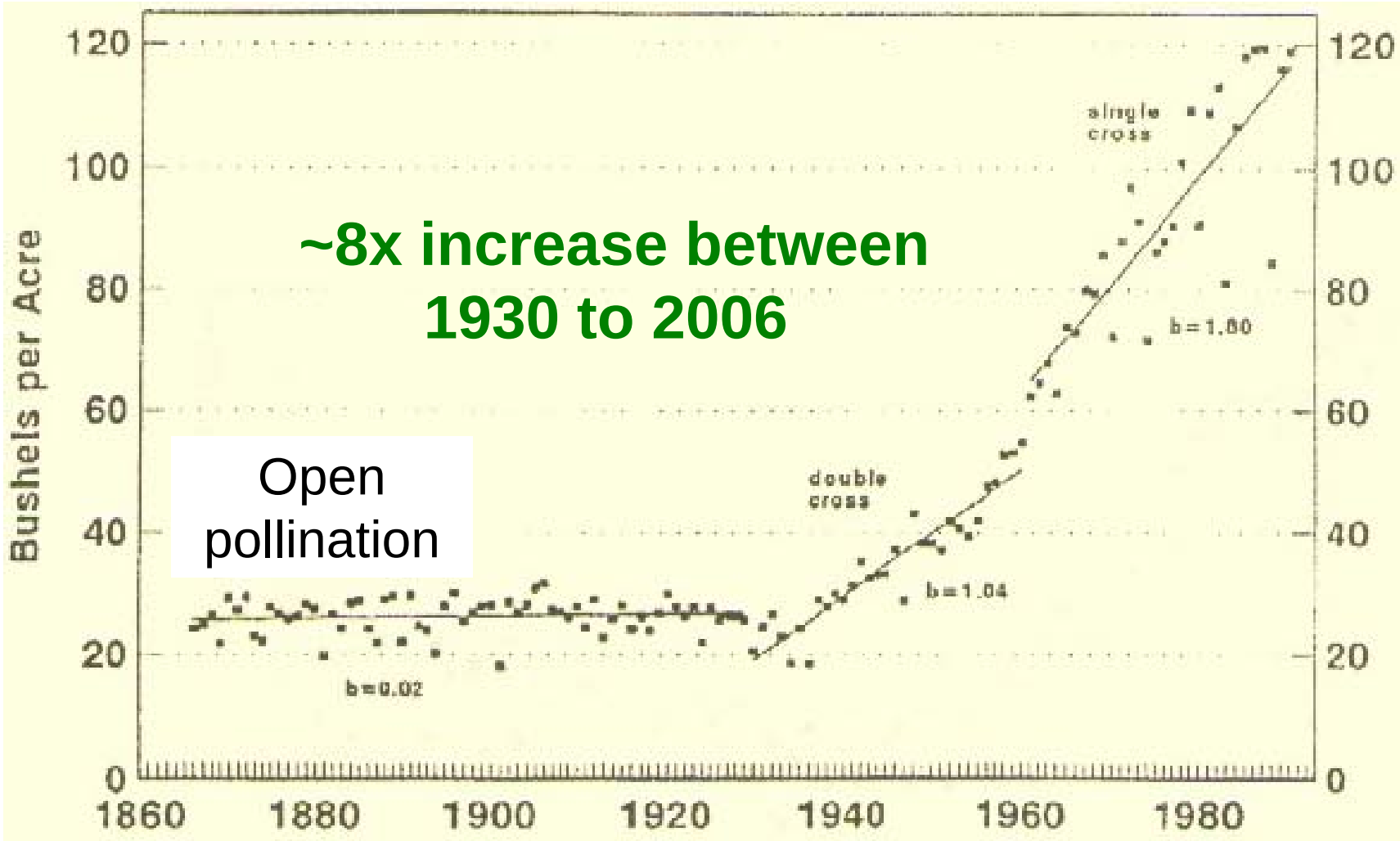
The Molecular Foundry ($20 M / year)

Director, Carolyn Bertozzi

Paul Alvisatos, Associate Lab
Director Physical Science



Average production of corn per acre in the United States



(Original figure from Tollenaar, as cited by McLaughlin, 2004).

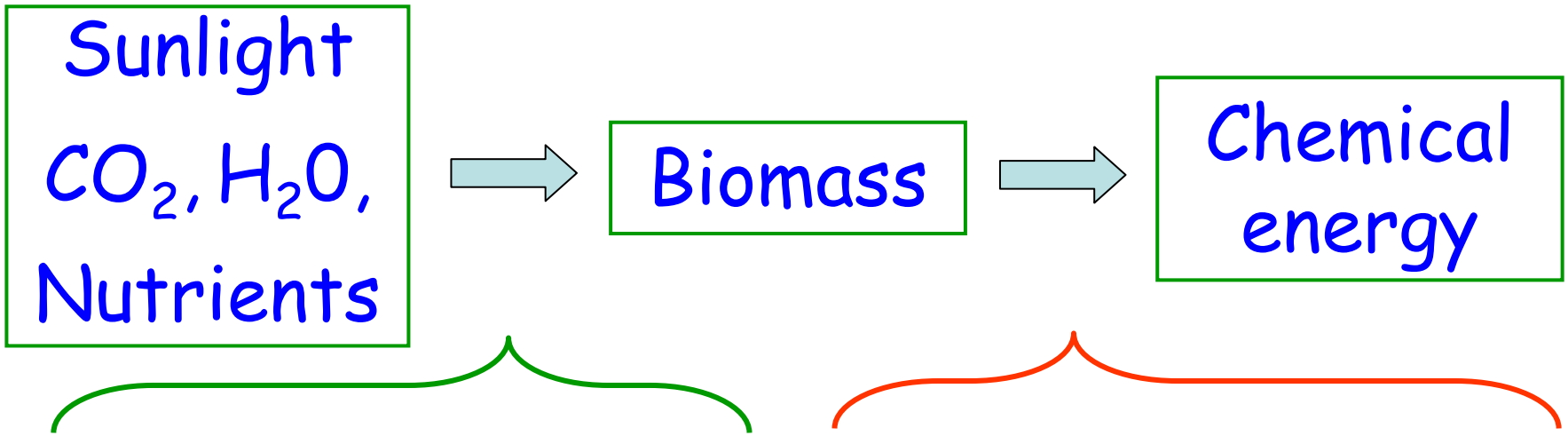
Total Surface Area by Land Cover/Use and Year in Millions of Acres, with Margins of Error

Year	Cropland*	CRP Land*	Pastureland	Rangeland
1982	419.9 ± 2.1	0.0 ± 0.0	131.1 ± 1.4	415.5 ± 3.5
1992	381.3 ± 2.0			
1997	376.4 ± 2.0			
2001	369.5 ± 2.0			
2003	367.9 ± 2.4	31.5 ± 0.3	117.0 ± 1.8	405.1 ± 3.5

52 million acres cropland has been taken out of production between 1982 and 2003. Another 31 million acres were converted into conservation preserves.

Source: US Dept of Agriculture

Sunlight to energy via Bio-mass



More efficient use of water, sunlight, nutrients.

Drought and pest resistant

Improved conversion of cellulose into fuel.
New organisms for biomass conversion.

Ultimately, the ***economics*** of bio-fuels will be governed by the availability of water and sunlight.

- Miscanthus yields**:** **26** dry tons/acre demonstrated
  (Official DOE and USDA estimate uses **8** dry tons/acre)

- 100 M acres $\Rightarrow$ ~ 200 B gal / year of ethanol

- US consumption (2004) = 141 B gal of gasoline
  ~ 200 B gal of ethanol / year

> 2% conversion efficiency was demonstrated on non-irrigated, non-fertilized test field in Illinois.

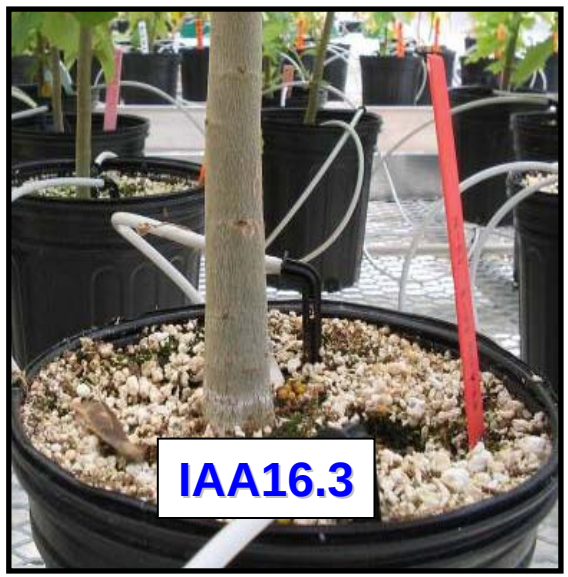
Courtesy Steve Long, UIUC

JGI DOE JOINT GENOME INSTITUTE US DEPARTMENT OF ENERGY OFFICE OF SCIENCE

Poplar tree

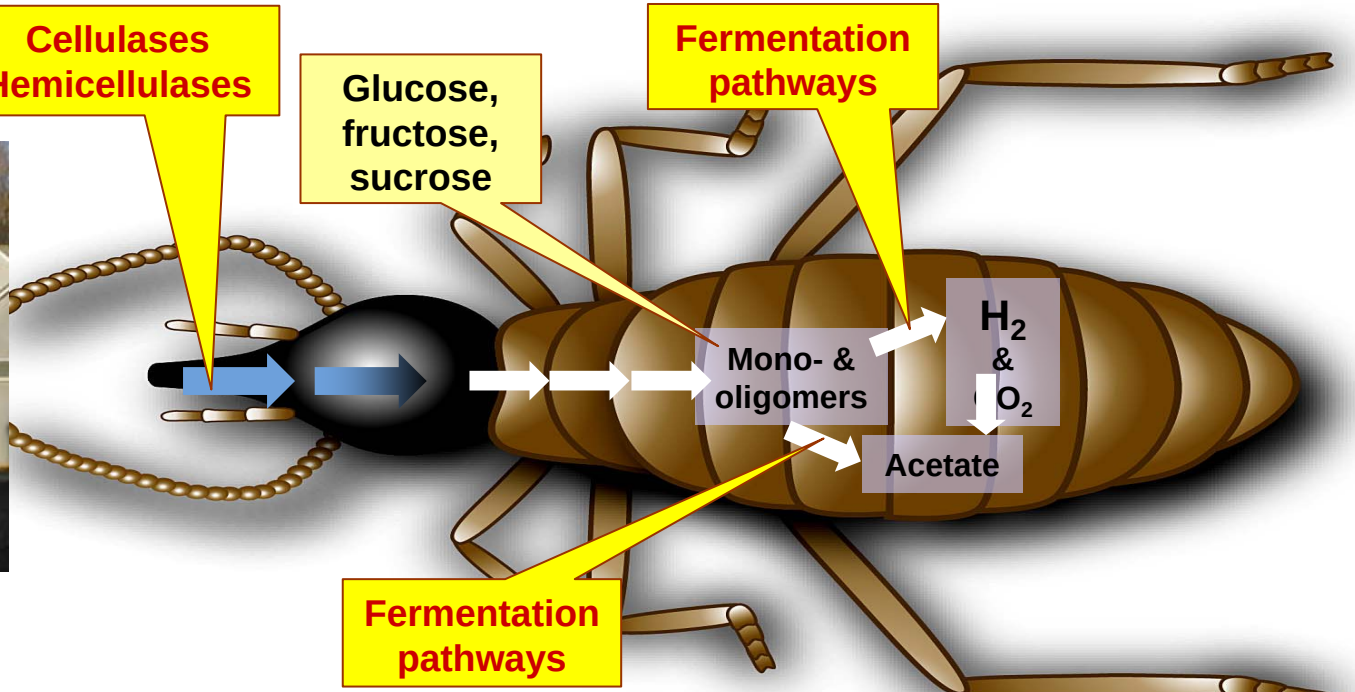
ornl OAK RIDGE NATIONAL LABORATORY | GenomeCanada | UPSC | UNIVERSITEIT GENT

- ~ 45,000 genes
- Improve drought resistance and long term carbon sequestration
- Improve bio-mass production.



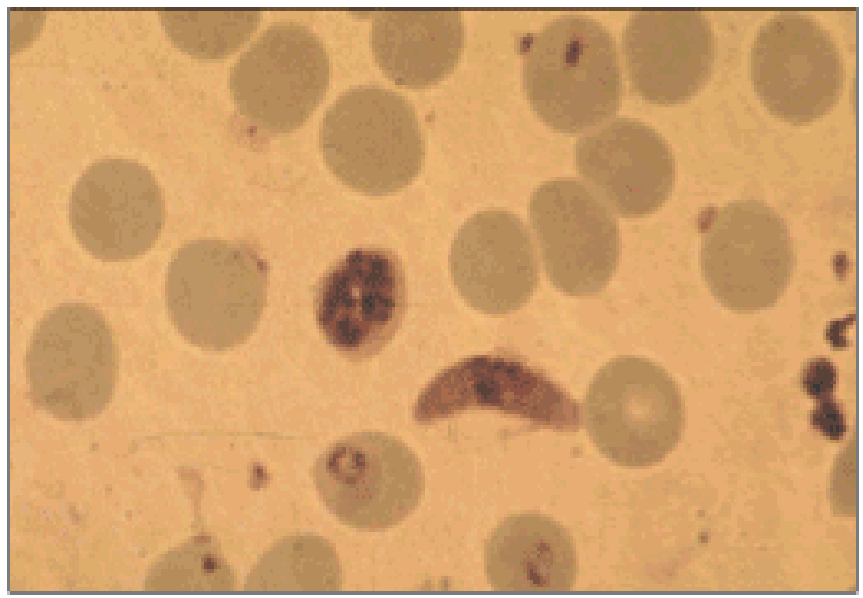
Termites have many specialized enzymes for efficiently digesting lignocellulosic material

JGI
DOE JOINT GENOME INSTITUTE
US DEPARTMENT OF ENERGY
OFFICE OF SCIENCE



Malaria

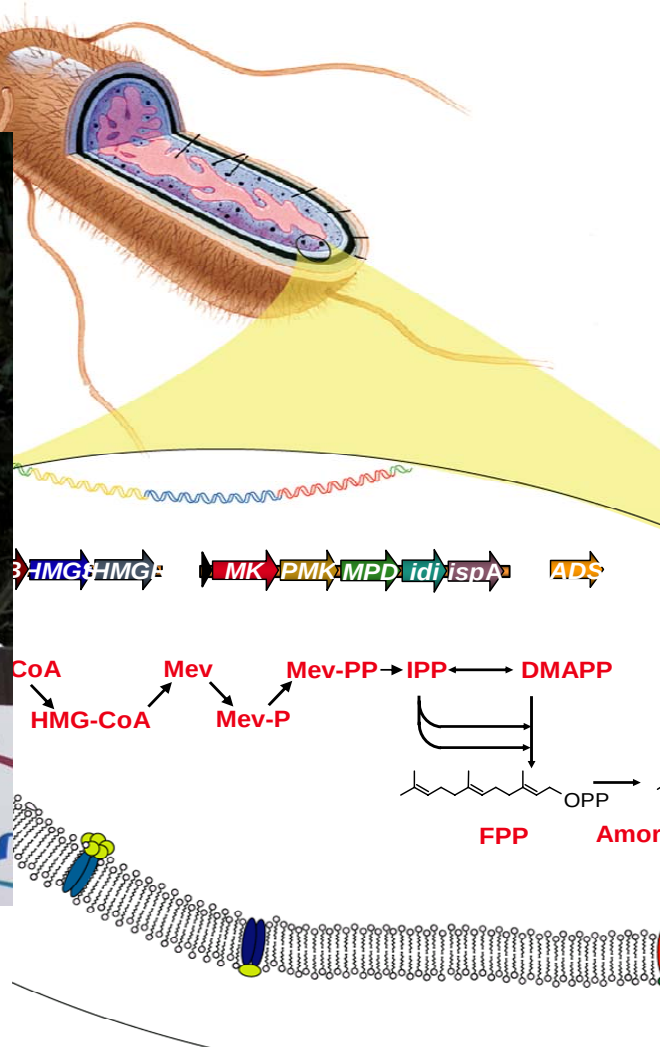
- Caused by *Plasmodium*, a single-cell protozoan
  - Transmitted by Anopheles mosquito
  - Destroys red blood cells
  - *Plasmodium* in South America and Southeast Asia is largely resistant to chloroquine – based drugs

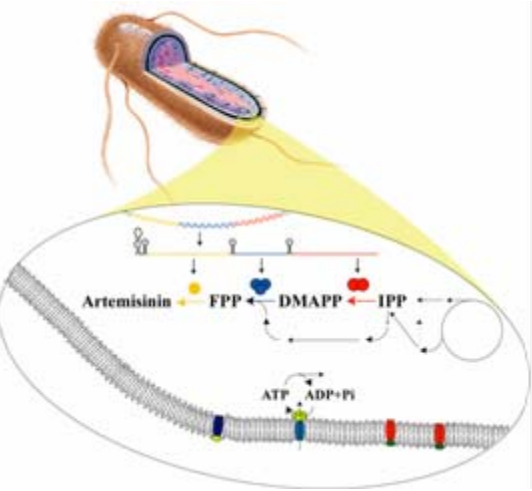


Production of artemisinin in bacteria

Jay Keasling

Director of Physical Biosciences Division





Synthetic Biology
Anti-malarial drugs from microbes

Early milestone completion due to careful project management!

Milestone

Pathway elucidation and cloning of genes

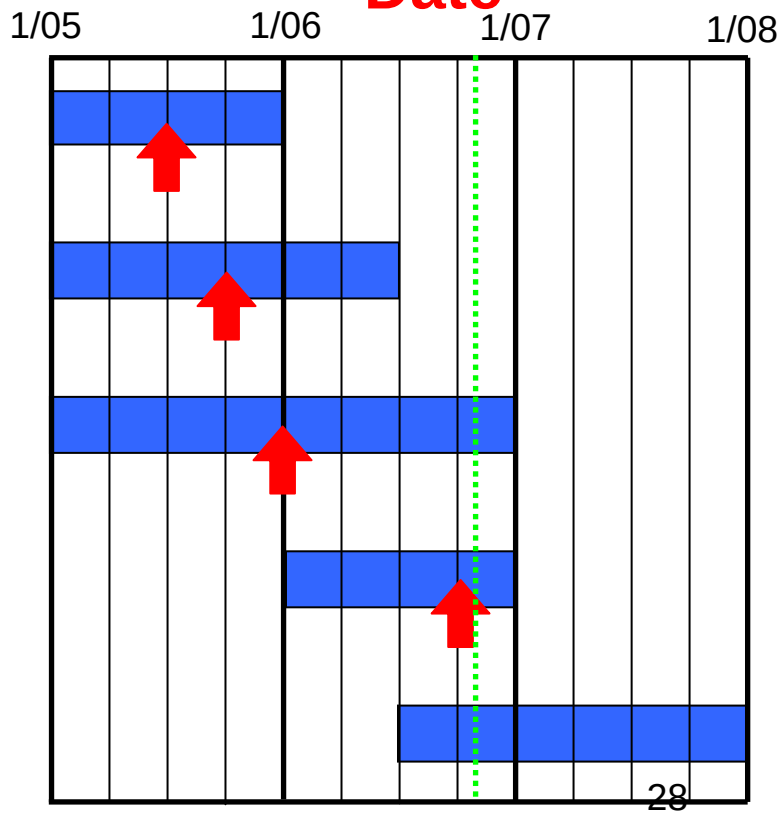
Functional expression of genes

Production of amorphadiene at 25 g/L

Production of artemisinic acid at 100 mg/L

Production of artemisinic acid at 25 g/L

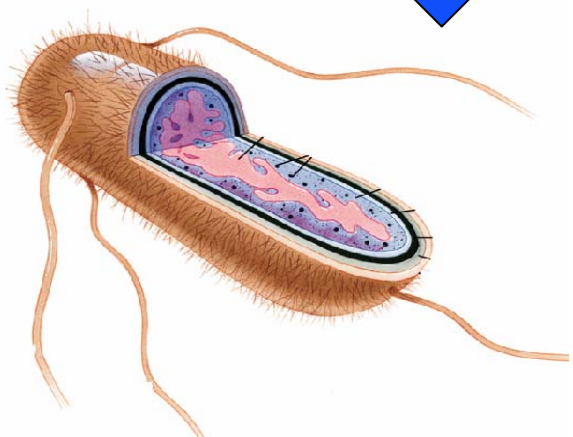
Date



= proposed work period

= milestone completion

Research, Development & Delivery



Keasling Laboratory

Amyris Biotechnologies

Institute for OneWorld Health

Cost 20¢ /cure

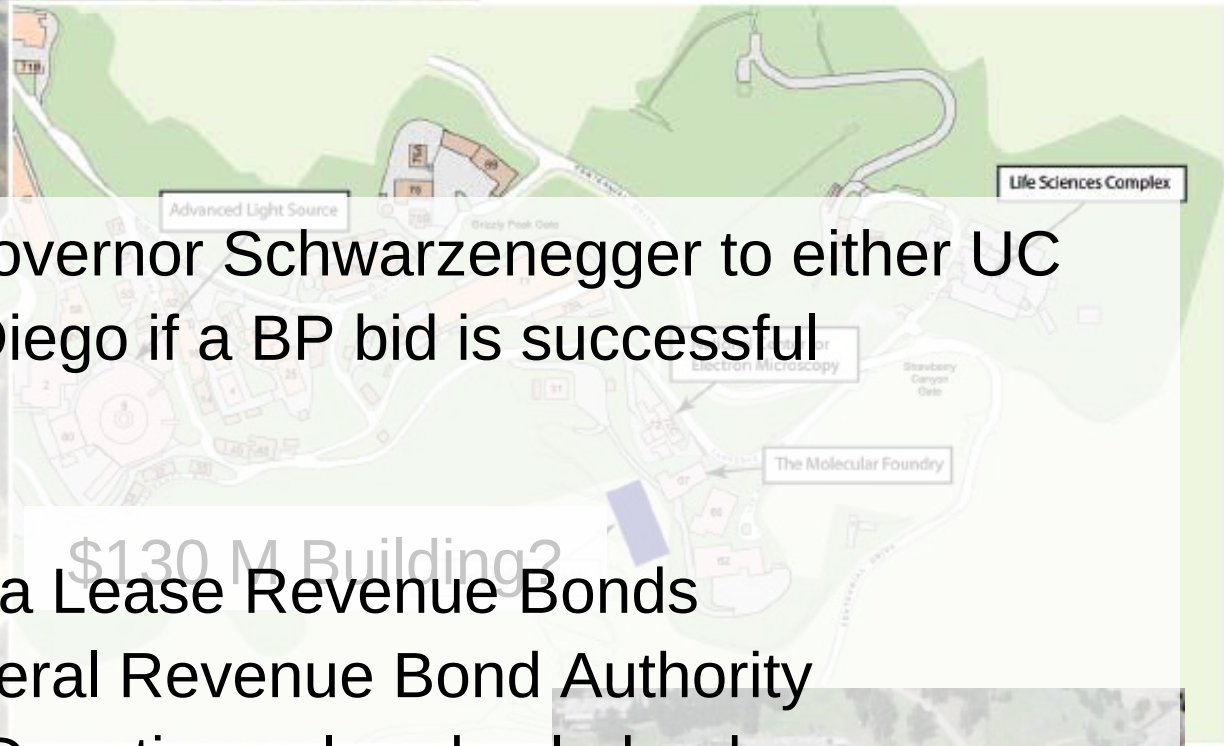
Microbial fuel synthesis

- Bio-prospect for new pathways and build *de novo,* non-natural pathways.
- Understand fuel toxicity and engineering tolerance and/or self-separation of the fuel.
- Develop the scientific tools that will form the basis for “industrial strength” synthetic biology systems.

Potential sources of funding

- BP: $500 M / 10 years
  (UC Berkeley and UC San Diego were two of the 5 institutions asked to bid)
- DOE: $125 M / 5 years
- State Support
- Foundation Support
- Private philanthropy
- Other industrial support

Proposed site of the Helios



$40 M Pledge from Governor Schwarzenegger to either UC Berkeley *or* UC San Diego if a BP bid is successful

Helios Fund raising:

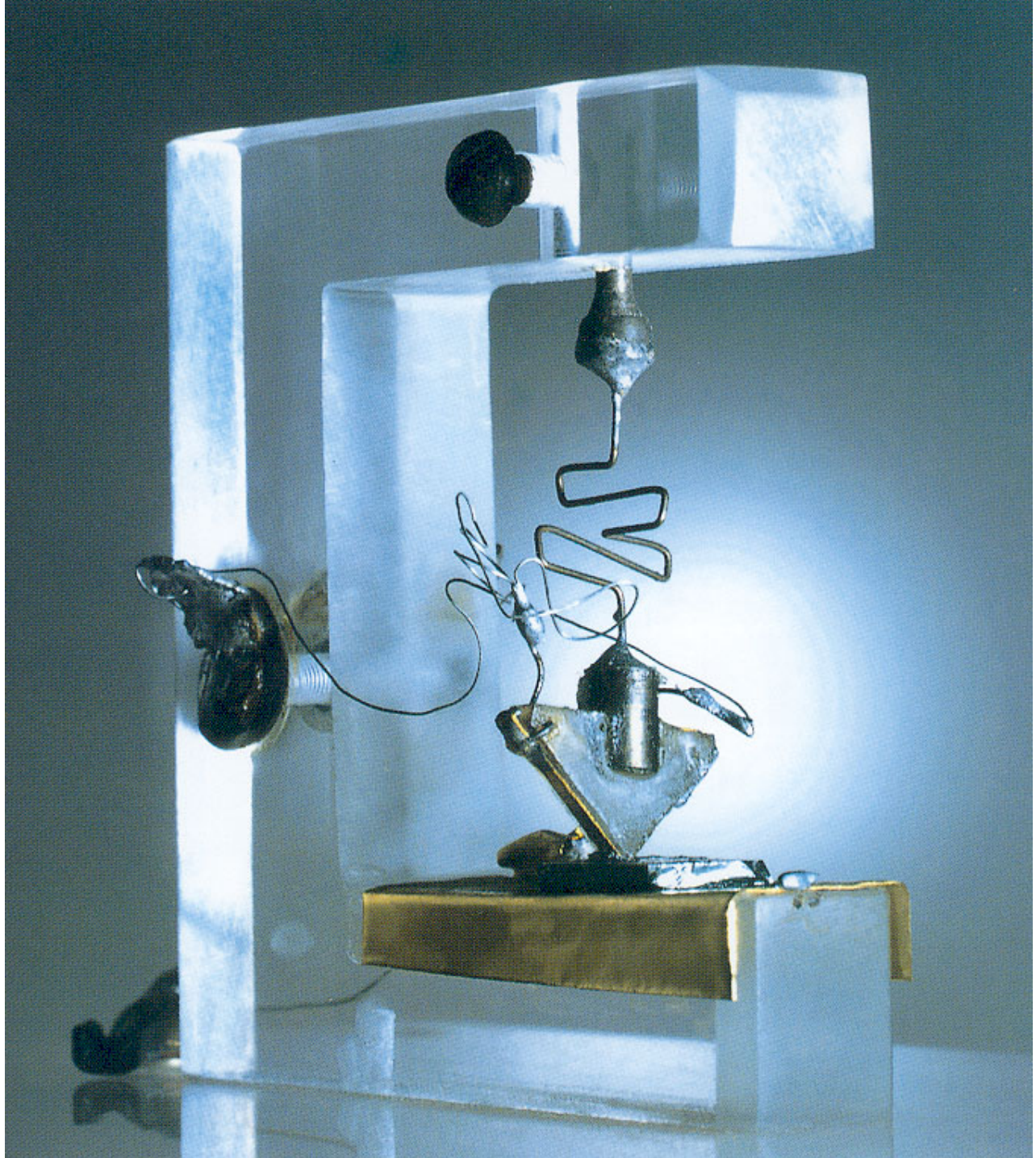
$30 M ?	California Lease Revenue Bonds
$30 M	UC General Revenue Bond Authority
$15 M	Private Donations already pledged
$1+1+2M	Private Donations 2007 scientific program
$ 3 M	Renewable Energy Chair
$10 M ?	Public Utilities Commission
$XX M?	Private Foundations

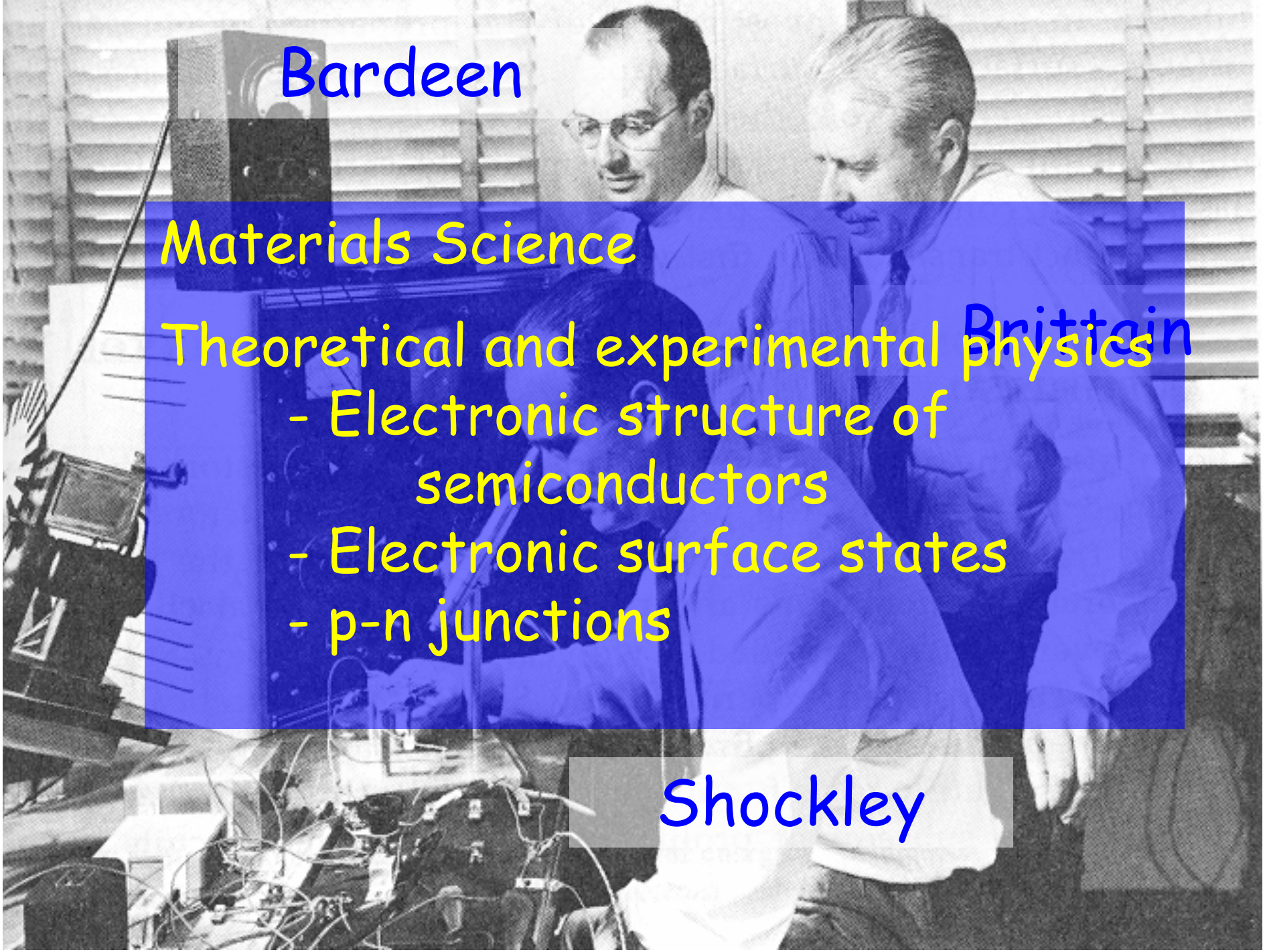
Los Alamos

1942 -1945

Bell Laboratories (Murray Hill, NJ)

15 scientists who worked at AT&T Bell laboratories received Nobel Prizes.




Bardeen
Materials Science
Theoretical and experimental physics
- Electronic structure of semiconductors
- Electronic surface states
- p-n junctions
Brittain
Shockley

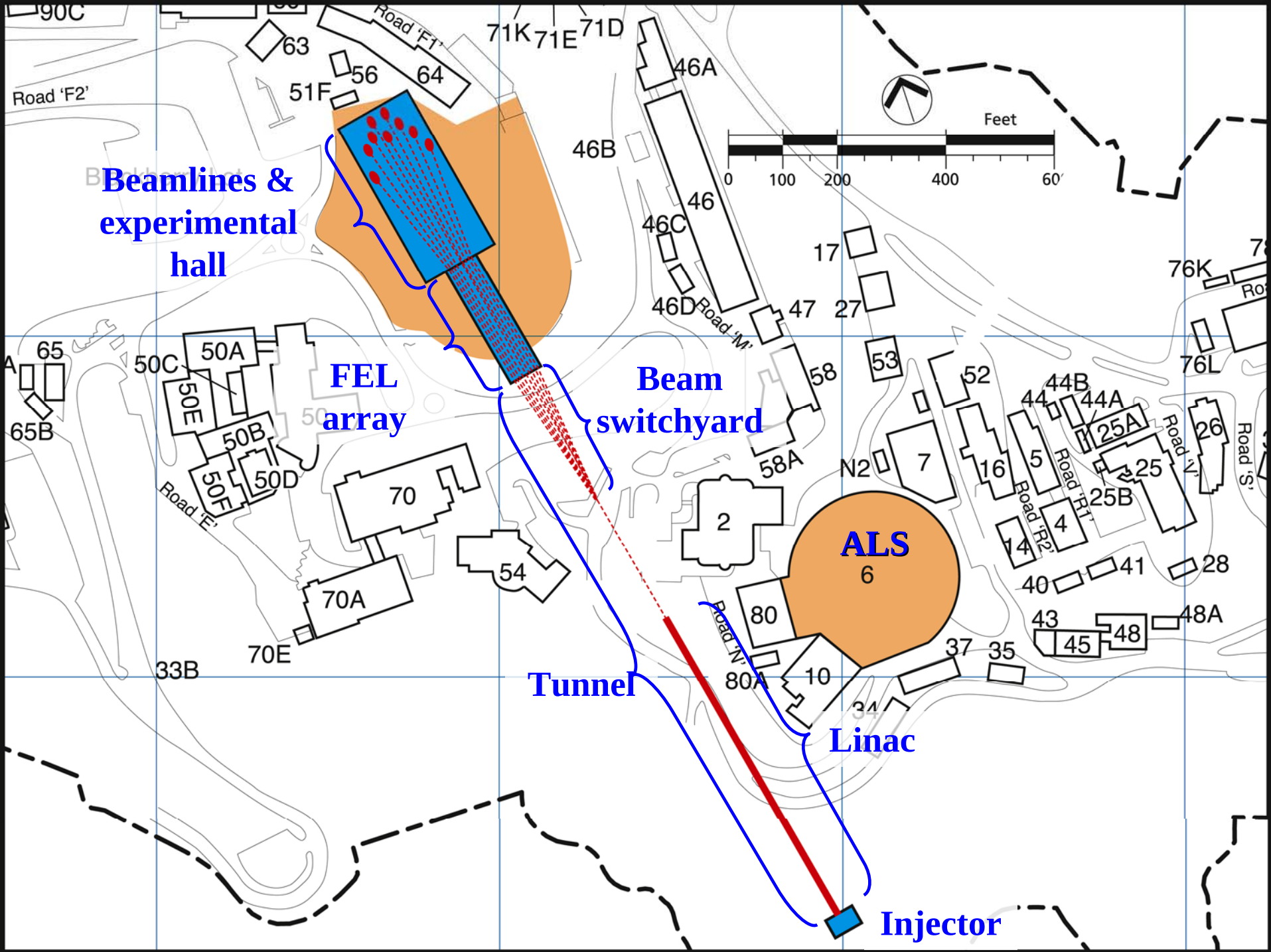
Organizational culture

- Individual genius was nurtured, but individuals were also encouraged to quickly form teams to rapidly exploit ideas.
- The scientific direction was guided by collective wisdom and “managed” by top scientists with intimate, expert knowledge.
- Bold approaches were encouraged; some failure was expected, but there was an emphasis on recognizing failure quickly, and moving on to other opportunities.

Proposed Computational Research & Theory

The CRT program

- **Strengthen the partnership with UCB computational and engineering programs**
- **Move the NERSC program back to the Main Site**
- **$90M facility; $80M from UC Bonds and $10M from gifts**
- **143,000 SF of computer floor and office space**


Beamlines & experimental hall
FEL array
Beam switchyard
ALS
Tunnel
Linac
Injector
Road 'F1'
Road 'F2'
Road 'E'
Road 'M'
Road 'N'
Road 'R1'
Road 'R2'
Road 'V'
Road 'S'
Feet
0
100
200
400
63
64
56
51F
71K
71E
71D
46A
46B
46
46C
46D
47
27
17
76K
76L
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65B
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50A
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25A
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48A